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Borage Agronomy and Harvesting Trials

1987

Research Contract

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SASKATCHEWAN AGRICULTURE
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by

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ABSTRACT

Borage is a semi-domesticated herb crop from which an oil rich in GLA (Gamma Linolenic Acid) is extracted. The crop has an indeterminate flowering pattern, making it difficult to harvest. One year's data indicates that vine ripened seeds have 2% more oil and 1.1% less GLA than seeds that are swathed and threshed. Yields declined when the crop was swathed after September 1, 1987, at Alvena and D'Arcy. Maximum yield calculated from seed that fell into trays was 1197 kg/ha or 1066 lb/ac compared to 373 kg/ha or 332 lb/ac from a swathed crop. Poast and Verdict had excellent crop tolerance but all broadleaf herbicides tested seriously damaged the borage.

A seed catcher was developed to catch the seeds that are knocked off the plants while swathing. After many modifications, a successful canvas/finger screen type unit was built and tested. Preliminary tests showed that it would save about $36.^{00}$ per acre.

Seed moisture curves for a Motomco Model 919 and SED 35 Moisture Meter were developed and distributed to the growers before harvest.

This project was conducted by R. Barry Rogers, P. Eng., M. Sc.; Dr. B. Irvine, Phd., P. Ag.; L. Bugeaud, BSA; B. Rinholm, BSAE and D. Olson, BSAE.

Non-Technical Report - Borage Growing

Based on our limited knowledge gained from this study and others, growers should consider the following. Extensive research in many areas is required before reliable recommendations can be made.

1. Plant borage with wheat equipment at 10 kg/ha. Low amounts of fertilizer have not retarded germination.

2. Poast or Verdict can be used as a gramicide. No broadleaf herbicides have been identified to date.

3. Borage is a poor competitor until after it bolts in late June. Most weeds will be well established by then, so it should be planted in very clean fields.

4. Bees are required to pollinate borage, about 2 hives per hectare, from the start of flowering until swathing (July 1 to August 30).

5. The flowering is indeterminate and seeds set, mature and fall off approximately 3 days after ripening. Mid-August to late August, in 1988, was the best time to swath.

6. Use a seed catcher to catch the seeds that fall on the swather canvas.

7. Seed moisture should be less than 10% for storage, calibration curves are available from Motomco and Filed No. 35 Moisture Meters.

8. The crop is slightly less tolerant to moisture stress than wheat.

SUMMARY

Borage is a semi-domesticated herb crop from which an oil rich in GLA (Gamma Linolenic Acid) is extracted. The crop has an indeterminate flowering pattern, making it difficult to harvest. This is the first research done on borage in Canada. Very little information exists on growing it anywhere in the world.

One year's data indicates that vine ripened seeds have 2% more oil and 1.1% less GLA than seeds that are swathed and threshed. Yields declined when the crop was swathed after September 1, 1987, at Alvena and D'Arcy. Maximum yield calculated from seed that fell into trays was 1197 kg/ha or 1066 lb/ac compared to 373 kg/ha or 332 lb/ac from a swathed crop. Poast and Verdict had excellent crop tolerance but all broadleaf herbicides tested seriously damaged the borage.

A seed catcher was developed to catch the seeds that are knocked off the plants while swathing. After many modifications, a successful canvas/finger screen type unit was built and tested. Preliminary tests showed that it would save about $36.^{99}$ per acre. The unit is simple and could be adapted to almost any swather. A retail selling price is estimated to be less than $1,000.^{99}$.

Seed moisture curves for a Motomco Model 919 and SED 35 Moisture Meter were developed and distributed to the growers before harvest.

The experiments done by Rogers Engineering Inc. in 1987 with borage adds to the growing database being developed by other researchers, such as Dr. Klehn of the Morden Research Station (see Appendix No. 1) and Dr. Simons of Purdue University.

This project was conducted by R. Barry Rogers, P. Eng., M. Sc.; Dr. B. Irvine, Phd., P. Ag.; L. Bugeaud, BSA; B. Rinholm, BSAE and D. Olson, BSAE.

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1. Oil Quality of Swathed vs. Vine Ripened Seed

Objective

To record both quality and quantity of seeds which mature on the plants and fall to the ground, as compared to seeds which remain on the swathed plants to cure.

Materials and Methods

The initial replicates of borage seeded for the experiment germinated poorly as a result of so little precipitation in the spring. Consequently, an alternative site was chosen in a field of borage owned by Julius Tristchuk near Alvena, Saskatchewan. Twelve rectangular wooden trays, with a nylon mesh screen bottom, were built. Each measured 20 x 122 cm representing .25 square metre. They were laid flat on the ground between the rows of borage plants. Some plants were removed in order that the trays could sit squarely between the rows. The seeds which fell on to the screens were collected every third day from August 14 through September 24. The seeds from each individual tray were weighed and the total of all twelve trays was recorded for that date. The samples were then sent to P.O.S. in Saskatoon where they were analyzed for gamma linolenic acid and oil content.

Whenever the trays were emptied, a 2.0 metre square area of borage was harvested by hand and put into heavy cloth bags, which were hung to dry for four weeks. They were threshed with a Kincaid plot combine, their weight was recorded, and samples were sent to P.O.S. for qualitative analysis along with the seed collected from the trays.

Results

The experiment confirms the observation that a large number of ripe seeds are lost due to shedding. If all of the seeds which end up on the ground were harvested, yields could be trippled from 373 kg/ha for swathed to 1197 kg/ha for total yield using this year's data. A study by Klehn of the Morden Research Station supports this hypothesis, and is described in detail in Appendix No. 1.

The seeds, which were collected in the trays, increased from the first date of collection till they reached a peak on September 4 and, thereafter, began to decrease till very few were collected on the final date. Similar results were evident in experiment No.3.

The threshed plants gave high yields from the onset but began to decrease dramatically after September 1. The final two dates yielded only a fraction of the initial yields.

The analysis of the borage seeds by P.O.S. revealed differences between the seeds collected from the threshed plants and those collected from the trays. The seeds, which fell on to the screens, had a higher oil content 37.9 as compared to 35.0 but were lower in GLA, averaging 21.1% as compared to 22.2% for the seeds from the threshed plants. Oil content decreased steadily for both sources of seeds as date of collection proceeded from August 14 to September 24. The GLA content was not appreciably altered for either source of seeds when these were collected in August and compared to seeds collected in September.

Conclusion

Oil quality is not affected by timing or method of harvest. Swathing in the last two weeks of August, in 1988, gave a maximumm yield which dropped off sharply for trials in September.

Recommendations

These studies need to be expanded to determine the best time to swath to maximize GLA and oil content. This is not necessarily maximizing yield. Future research needs to determine if there is a correlation between the activity of bees, environment, yields, oil content, and reduced seed drop. In seed alfalfa production, the heavy pressure of bees on the flowers during early bloom can improve yields and reduce seed drop. It is speculated that borage yields and shattering loss can also be influenced by bee activity. In future research intense bee activity could be simulated by screening areas and then forcing the bees to work them intensely by putting hives inside the screens. The yield and seed drop would be monitored as the crop matures.

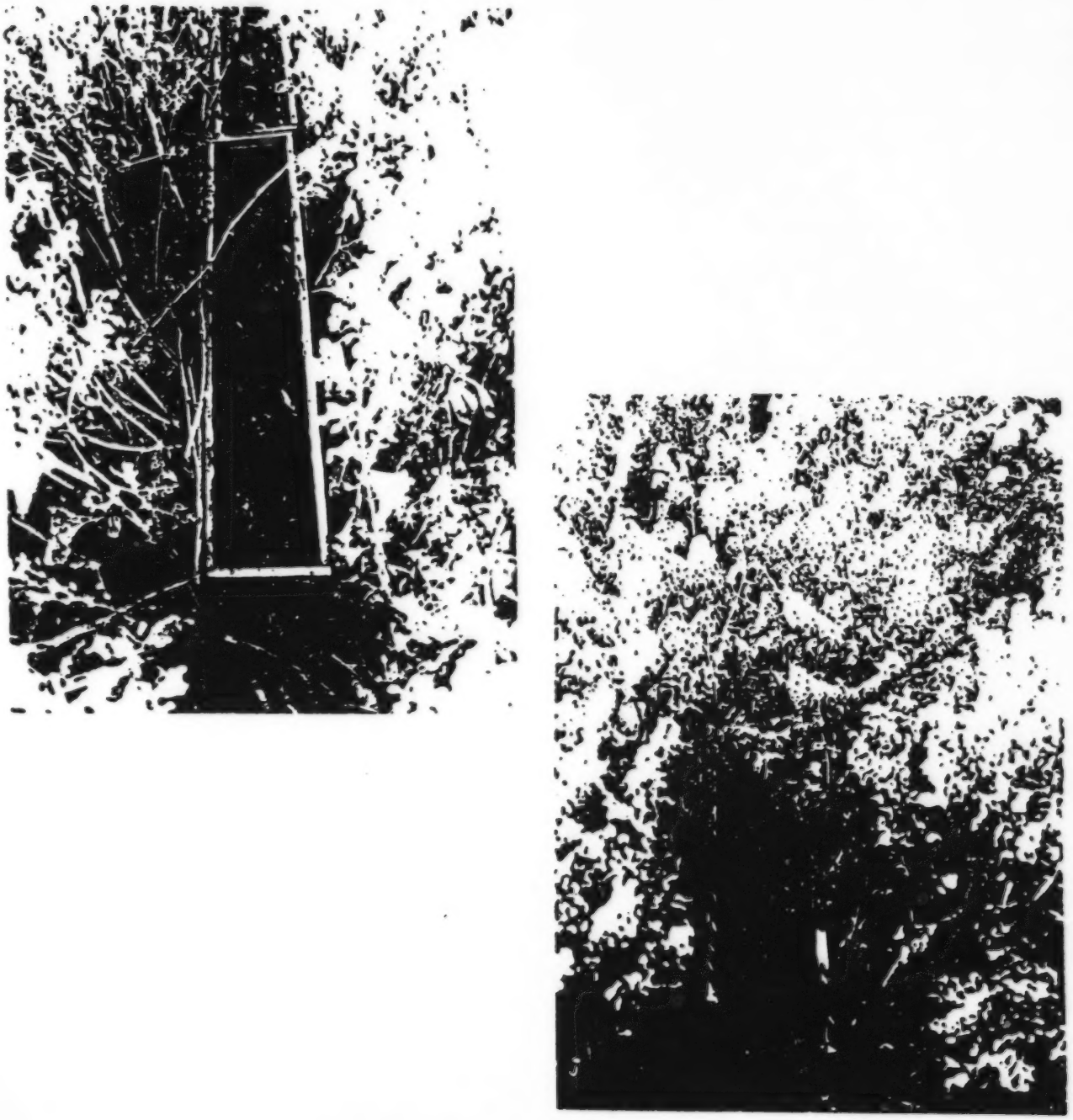


FIGURE 1: POSITIONING OF TRAYS TO CATCH BORAGE SEED

BORAGE AGRONOMY AND HARVESTING TRIALS 1987

1. OIL QUALITY OF SWATHED VS. VINE RIPENED SEED

TABLE 1: YIELDS OF ALVENA BORAGE SAMPLES FROM THRESHED PLANTS

DATE	WEIGHT (g)	CONVERSION Kg/ha (lbs/ac)
August 14	67.9	340 (303)
August 17	62.3	312 (278)
August 20	72.0	360 (321)
August 23	66.0	330 (294)
August 26	74.6	373 (333)
August 29	47.6	240 (214)
September 1	64.4	320 (285)
September 4	23.2	115 (103)
September 8	29.8	150 (134)
September 11	28.1	140 (125)
September 14	18.9	95 (85)
September 17	13.1	65 (58)
September 21	5.4	27 (24)
September 24	7.9	40 (36)

NOTES: HARVESTED AREA WAS 2.0 SQUARE METERS.

1. OIL QUALITY O OF SWATHED VS. VINE RIPENED SEED

TABLE 2: WEIGHT OF BORAGE FROM TRAYS

DATE	TOTAL WT. OF BORAGE FROM 12 TRAYS (in grams)	CONVERSION Kg/ha (lbs/ac)
August 14	11.72	40 (36)
August 17	12.74	42 (38)
August 20	17.12	57 (51)
August 23	37.33	124 (111)
August 26	37.29	124 (111)
August 29	36.54	122 (109)
September 1	42.53	142 (127)
September 4	45.26	151 (135)
September 8	37.18	124 (111)
September 11	18.99	63 (56)
September 14	27.94	93 (83)
September 17	10.11	34 (30)
September 21	17.48	58 (52)
September 24	6.96	23 (21)

NOTES: WEIGHT CONVERSIONS ARE CONSERVATIVE ESTIMATES OF YIELD.

1. OIL QUALITY OF SWATHED VS. VINE RIPENED SEED

TABLE 3: PRECIPITATION DATA FOR ALVENA, SASK.
(April 1 - Sept. 30,1987)

DATE	(mm)	DATE	(mm)	DATE	(mm)	DATE	(mm)	DATE	(mm)	DATE	(mm)
April 1	-	May 1	-	June 1	19.0	July 1	10.0	Aug. 1	-	Sept. 1	-
April 2	-	May 2	-	June 2	2.0	July 2	-	Aug. 2	7.0	Sept. 2	-
April 3	-	May 3	7.0	June 3	-	July 3	3.0	Aug. 3	-	Sept. 3	10.0
April 4	-	May 4	-	June 4	-	July 4	-	Aug. 4	-	Sept. 4	-
April 5	-	May 5	-	June 5	-	July 5	1.0	Aug. 5	7.0	Sept. 5	-
April 6	-	May 6	-	June 6	-	July 6	11.0	Aug. 6	-	Sept. 6	2.0
April 7	-	May 7	-	June 7	-	July 7	-	Aug. 7	-	Sept. 7	-
April 8	-	May 8	-	June 8	-	July 8	3.0	Aug. 8	-	Sept. 8	-
April 9	2.0	May 9	-	June 9	-	July 9	1.0	Aug. 9	-	Sept. 9	5.0
April 10	-	May 10	-	June 10	21.0	July 10	-	Aug. 10	17.0	Sept. 10	-
April 11	-	May 11	-	June 11	-	July 11	-	Aug. 11	3.0	Sept. 11	-
April 12	-	May 12	-	June 12	-	July 12	-	Aug. 12	1.0	Sept. 12	-
April 13	-	May 13	-	June 13	-	July 13	9.0	Aug. 13	-	Sept. 13	-
April 14	-	May 14	-	June 14	-	July 14	1.0	Aug. 14	2.0	Sept. 14	-
April 15	2.0	May 15	-	June 15	-	July 15	-	Aug. 15	5.0	Sept. 15	-
April 16	-	May 16	-	June 16	-	July 16	1.0	Aug. 16	-	Sept. 16	-
April 17	-	May 17	-	June 17	-	July 17	1.0	Aug. 17	-	Sept. 17	-
April 18	3.0	May 18	-	June 18	-	July 18	-	Aug. 18	-	Sept. 18	-
April 19	-	May 19	-	June 19	1.0	July 19	25.0	Aug. 19	-	Sept. 19	-
April 20	-	May 20	-	June 20	3.0	July 20	3.0	Aug. 20	3.0	Sept. 20	-
April 21	-	May 21	-	June 21	1.0	July 21	-	Aug. 21	-	Sept. 21	-
April 22	-	May 22	-	June 22	-	July 22	-	Aug. 22	-	Sept. 22	-
April 23	-	May 23	-	June 23	-	July 23	-	Aug. 23	-	Sept. 23	-
April 24	5.0	May 24	-	June 24	2.0	July 24	-	Aug. 24	-	Sept. 24	-
April 25	-	May 25	-	June 25	-	July 25	-	Aug. 25	2.0	Sept. 25	-
April 26	-	May 26	-	June 26	-	July 26	-	Aug. 26	-	Sept. 26	-
April 27	-	May 27	4.0	June 27	12.0	July 27	-	Aug. 27	-	Sept. 27	-
April 28	-	May 28	14.0	June 28	-	July 28	-	Aug. 28	3.0	Sept. 28	-
April 29	-	May 29	-	June 29	2.0	July 29	3.0	Aug. 29	-	Sept. 29	-
April 30	-	May 30	-	June 30	-	July 30	12.0	Aug. 30	-	Sept. 30	-
		May 31	4.0			July 31	-				

NOTES:

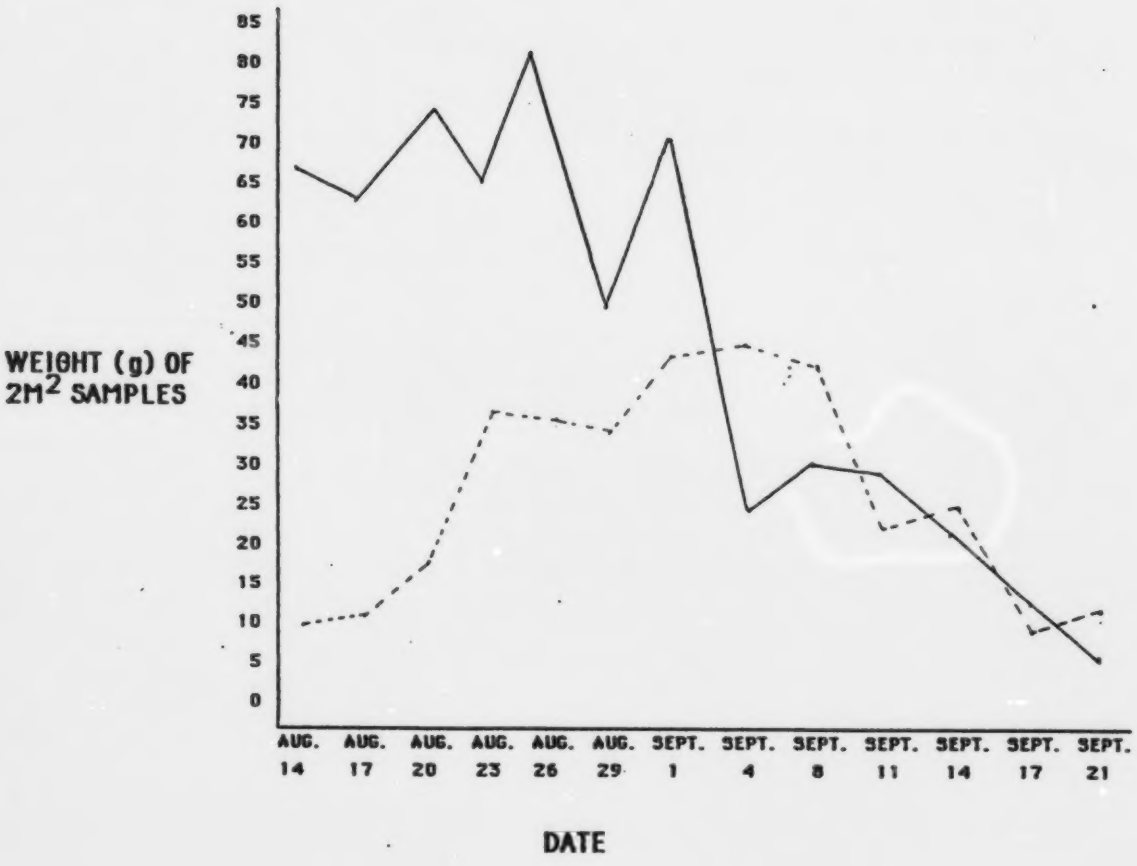
TOTAL PRECIP. FOR APRIL 1 - SEPT. 30 AT ALVENA,SASK. = 256.0 mm.

BORAGE AGRONOMY AND HARVESTING TRIALS 1987

1. OIL QUALITY OF SWATHED VS. VINE RIPENED SEED

TABLE 4: ANALYSIS OF BORAGE SEED BY POS

SEEDS FROM THRESHED PLANTS				SEEDS FROM TRAYS			
DATE	WEIGHT (g)	% OIL DRY BASIS	% GLA	DATE	WEIGHT (g)	% OIL DRY BASIS	% GLA
August 14	67.9	36.1	22.9	August 14	11.7	37.8	21.0
August 17	62.3	37.2	22.8	August 17	12.7	38.6	21.0
August 20	72.0	35.8	22.7	August 20	17.1	38.1	20.7
August 23	66.0	35.9	22.6	August 23	37.3	38.8	22.0
August 26	74.6	34.5	21.8	August 26	37.2	38.8	21.5
August 29	47.6	33.9	22.5	August 29	36.5	37.7	20.6
September 1	64.4	35.5	21.5	September 1	42.5	36.5	19.9
September 4	23.2	35.3	21.4	September 4	45.2	37.0	20.2
September 8	29.8	35.0	22.2	September 8	37.1	36.5	20.5
September 11	28.1	36.1	21.6	September 11	18.9	36.6	20.5
September 14	18.9	35.4	22.5	September 14	27.9	36.7	21.4
September 17	13.1	34.9	22.8	September 17	10.1	36.0	21.8
September 21	5.4	32.1	21.7	September 21	17.4	34.7	22.4
September 24	7.9	32.5	21.9	September 24	6.9	33.9	22.2
	MEAN =	35.0	22.2		MEAN =	37.0	21.1



LEGEND

——— **Represents:** Seed Weight of $2m^2$ Borage Samples From Alvena Versus Date

----- **Represents:** Total Yield Weight of 12 Trays ($3m^2$) at Alvena, Saskatchewan

FIGURE 2: SEED WEIGHT OF BORAGE SAMPLES VERSUS SEED WEIGHT FROM TRAYS

2. Herbicide Screening

Objective

To determine the tolerance of borage to various herbicides.

Materials and Methods

The experiment was conducted 5 km east of Saskatoon, on a dark brown soil with a loam texture. The previous crop was spring wheat. The experiment was a randomized complete block with four replicates. Plot size was 3 x 5m. On May 21, borage was sown across the replicates with a hoe drill, at a depth of 3 cm and a rate of 25 kg/ha. Fertilizer was applied with the seed at rates of 45 lbs/ac for N and 20 lbs/ac for P. The borage emerged within 14 days of planting.

Precipitation as a percentage of normal was 81, 44, 69, and 100% for the months May through August, respectively. The rains received in May, June, and July were light and evaporation was high; soil moisture never reached more than 4 cm until August. Hot, dry conditions in June provoked drought stress in crops and weeds at this site. Mean monthly temperatures for the months May, June, July, and August were 21, 26, 25, and 21° C, respectively.

Treatments 1 through 11, 21, 22 and 23 were applied June 19 at 2.00 p.m. The wind was southeast at 8 km/h, the temperature was 28 C, and relative humidity was 40%. The green foxtail was at the 4-leaf stage, the wild oats were at the 3-leaf stage, and the borage had 4-6 leaves. Treatments 12 through 18, 24 and 25 were applied June 26 at 4:00 p.m. The wind was 20 km/h from the west. Temperature was 26° C, and relative humidity was 30%. The green foxtail was in the 4-leaf stage and the borage had 4-6 leaves.

Evaluations

Crop tolerance and visual evaluations of weed control were taken 14 and 28 days after treatment. Weed control was based on the ability of the herbicide treatment to reduce wild oat and green foxtail populations. Those treatments, which achieved a high tolerance rating and a good degree of weed control, were harvested. Unfortunately, borage yields were very low at this site and residue analysis was impossible to perform on the samples.

Results and Discussion

Precipitation for the area was below normal for the month of June. Drought symptoms, such as drooping leaves and general lack of vigor in the borage plants, were observed several times during the month when high temperatures were recorded.

Borage showed fair to good tolerance to all grassy herbicides tested. Weed control with the grassy herbicides was good. Poast at half the recommended rate did as well and achieved the same amount of weed control as the full rate, while being very safe on the crop. Verdict gave excellent control of both wild oat and foxtail and a high tolerance rating. A third grass herbicide, which looks promising, is Cyanamid's new Assert. This chemical controlled wild oats, gave suppression of wild buckwheat, and was relatively safe on borage, although it is more phytotoxic to it than Poast or Verdict.

The borage showed poor to fair tolerance to the broadleaf herbicides tested. Some of the herbicides, such as Du Pont's Glean and Ally, completely killed the borage plants, as did the phenoxy herbicides (2,4-D, MCPA). The borage showed fair tolerance to Fusilade at the full rate and good tolerance to Fusilade at 75% of the recommended rate. Neither of these treatments gave good weed control, but this might be due to the droughted nature of the weeds and the late stage at which they were sprayed. Borage was tolerant to Lontrel herbicide. It was difficult to determine if seed set had been affected, since the borage plants suffered from drought and produced little seed whether treated or not. In 1986 it appeared to stop seed set.

Recommendations

The results of the 1987 screening study on borage suggest that most graminicides can safely be used as postemergent control of wild oats and other grassy species in borage. However, a postemergent broad-leaf herbicide, which can be safely used in borage, has yet to be found. Therefore, we propose a number of herbicides to try on borage in the spring of 1988. The main target weeds are wild buckwheat, lambs' quarters, and both species of pigweed. Most of these weeds are controlled by the following herbicides:

1.	asulam	ASULOX F	2.75 L/ha
2.	2,4-DB	EMBUTOX 625	1.75 L/ha
3.	metribuzin	LEXONE	275 g/ha
4.	linuron	LOROX L	1.0 L/ha
5.	picloram	TORDON 22K	0.1 L/ha
6.	trifluralin	TREFLAN	2.0 L/ha
7.	naptalam & dinoseb	DYANAP	-
8.	metribuzin/trifluralin	SENCOR 75DF/TREFLAN	275 g/ha/22g/ha

Most of these herbicides are postemergent and will be applied to the borage crop when it is in the 2-leaf stage. Treflan, Dyanap, and the Sencor/Treflan tank mix will be incorporated at depths of 3, 5, and 7 cm after application. The depth of the borage seed will be closely monitored to observe any responses that seed depth has to the degree of weed control from pre-emergent herbicides.

2. HERBICIDE SCREENING

TABLE 5: TREATMENT MEANS OF VISUAL EVALUATIONS FOR WEED CONTROL AND CROP TOLERANCE (28 DAT)

TRADE NAME	CHEMICAL NAME	RECOMMENDED RATE (L/Ha)	RATE OF APPL. AS % OF RR	RATE OF CARRIER (L/Ha)	SURFACTANT AT REC. RATE	CROP TOLERANCE	OAT AND FOXTAIL CONTROL
BROAD-LEAVED HERBICIDES							
1. BUCTRIL M	bromoxynil/MCPA	2.5	100	100	N/A	0.8	0.0
2. SWEEP	paraquat	2.2	100	100	N/A	5.0	8.8
3. SWEEP	paraquat	2.2	100	10	N/A	5.8	2.5
4. SWEEP	paraquat	2.2	25	10	N/A	6.5	6.3
5. GLEAN	chlorsulfuron	30 g/ha	50	100	N/A	0.0	0.5
6. GLEAN	chlorsulfuron	30 g/ha	100	100	N/A	0.0	0.5
7. ALLY	metsulfuron	45 g/ha	100	100	N/A	0.8	0.3
8. REFINE	exp. capd.	.112 g/ha	100	100	N/A	1.0	0.0
9. ULTIM	exp. capd.	.075 g/ha	100	100	N/A	1.5	0.0
10. 2,4-D	amine	1.5	33	100	N/A	1.5	0.3
11. 2,4-D	amine	1.5	100	100	N/A	0.5	1.0
12. TORCH	bromoxynil	1.5	100	100	N/A	0.0	0.0
13. BASAGRAN	bentazon	2.2	100	100	ASSIST	1.8	0.0
14. TORDON 202C	picloram/2,4-d	1.5	100	100	N/A	5.3	0.0
15. LONTREL	clopyralid	1.0	100	100	N/A	7.5	0.0
16. STAMPEDE	propanil	2.7	100	100	N/A	5.3	0.8
17. CURTAIL	clopyralid/MCPA	1.5	100	100	N/A	1.5	0.0
18. BANVEL	dicamba	2.7	100	100	N/A	1.5	2.5

BORAGE AGRONOMY AND HARVESTING TRIALS 1987

TRADE NAME	CHEMICAL NAME	RECOMMENDED RATE (L/Ha)	RATE OF APPL. AS % OF RR	RATE OF CARRIER (L/Ha)	SURFACTANT AT REC. RATE	CROP TOLERANCE	OAT AND FOXTAIL CONTROL
GRASSY	HERBICIDES						
19. POAST	sethoxydim	1.6	50	100	ASSIST	7.8	8.8
20. POAST	sethoxydim	1.6	100	100	ASSIST	8.3	9.0
21. HOEGRASS	diclofop-methyl	2.5	100	100	N/A	6.8	6.8
22. ASSERT	imazamethabenz	1.1	100	100	N/A	6.8	7.0
23. VERDICT	haloxyfop-methyl	0.5	-	100	N/A	8.5	9.0
24. FUSILADE	fluazifop-butyl	1.0	70	100	AGRAL 90	7.0	1.5
25. FUSILADE	fluazifop-butyl	1.0	100	100	AGRAL 90	5.5	2.8

NOTES: ALL TRTS. WERE APPLIED WITH SS80015 NOZZLES AT A PRESSURE OF 425 KPa WITH A SPEED OF 8 km/h TO DELIVER 100 L/Ha.

TRTS. #3 AND #4 WERE APPLIED WITH 800017 NOZZLES, AT A PRESSURE OF 690 KPa WITH A SPEED OF 13 km/h TO DELIVER 10 L/Ha.

3. Swathing Time for the Optimisation of Yield

Objective

The objective of this study is to examine the relation between time of swathing and its effect on yield.

Materials and Methods

Each grower harvested four samples of mature plants, each measuring 2 square metres. This was to be done at five intervals throughout the growing season, with the first "swathing" date occuring when 10% of the first seeds are ripe. Thereafter, borage samples were collected at weekly intervals. The borage plants were cut about 15 cms above the ground with a hand scythe or heavy scissors. They were carefully placed into heavy cloth bags provided by Rogers Engineering Inc. and hung to cure in a dry place. Each bag was labelled with the date and sample number they corresponded to. Once the samples were well dried, they were delivered to Rogers Engineering Inc., where they were threshed and the weight of each sample recorded. The results of this study were analyzed and reported upon.

Evaluation

The weight of the threshed samples was determined and arranged according to treatment (date harvested). The seeding date of each grower was recorded and an attempt was made to determine days to maturity, as well as the optimum swathing time based upon the yield of the threshed plants. An analysis of variance was performed on the yield data, including an LSD test and a Duncan's Multiple Range test, both done at the 5% level of significance. These statistical analyses permitted us to determine which of the treatment means were significantly different from each other.

Results and Discussion

The data generated from the samples collected show conclusively that although borage is a plant with an indeterminate flowering pattern, there was a period of increased seed production which occurred at about the twelfth week with this crop. The peak in seed production was observed toward the end of August. By early September, the yield of the threshed borage plant samples was reduced. Days to maturity would be about ninety-eight, based upon a seeding date of May 26, to the time when the majority of the borage seeds were mature September 1. Swathing borage in early August is too soon, since production has not reached its maximum.

Data indicated that the crop should be swathed between the dates of August 15-September 1, inclusive. Of course, this time period is only a rough estimate and may vary from year to year, depending upon the seeding date and environmental conditions throughout the growing season, as these will affect the rate of maturity of the borage. Each grower must carefully examine individual acreages regularly in August to determine the extent of seed production and the average stage of maturity of his borage crop.

Byrne Segen of Kenaston, Saskatchewan, harvested eight plants at four intervals, each five days apart. The borage plants were threshed and the total number of seeds from the eight plants were recorded for that replicate. This was done three additional times and a mean number of seeds per replicate (or plot) was arrived at for each date. There was a significant increase in the number of seeds when compared to the previous total each time the seeds were counted. This grower claims that his crop suffered from drought till late August, at which point some rain fell which initiated prolific seed production. On September 6, the last date that seed counts were taken, the plants had produced over double the amount of seeds that were recorded for August 22. Days to maturity were about ninety-nine. The crop was seeded May 23 and swathed September 1.

Only three of the growers responded to the study; Trischuk, Lloyd and Segen. Segen did not follow the procedure given to him so his data cannot be compared to the others. Rogers Engineering Inc. crop droughted out and was not worth sampling. The response indicates that it would be more reliable to have hired staff to do the sampling rather than rely on farmers who are very busy at this time of the year.

3. SWATHING TIME FOR THE OPTIMISATION OF YIELD

TABLE 6: WEIGHT OF BORAGE SAMPLES FROM D'ARCY, SK

TREATMENT	DATE	MEAN (g/sq. m.)	CONVERSION kg/ha (lbs/ac)
1	August 11	10.2 b	102 (91)
2	August 18	19.9 a	199 (175)
3	August 25	23.2 a	232 (204)
4	September 1	24.7 a	247 (217)
5	September 8	17.7 a	177 (156)

NOTES: TRT. MEANS SEPARATED BY DUNCAN'S MULTIPLE RANGE TEST AT THE 5% LEVEL

TABLE 7: WEIGHT OF BORAGE SAMPLES FROM ALVENA, SK

TREATMENT	DATE	MEAN (g/sq. m.)	CONVERSION kg/ha (lbs/ac)
1	August 14	34	340 (303)
2	August 20	36	360 (321)
3	August 26	37	373 (333)
4	September 1	32	320 (285)
5	September 8	15	150 (134)
6	September 14	9	95 (125)

3. SWATHING TIME FOR THE OPTIMISATION OF YIELD

TABLE 7: NO. OF SEEDS COLLECTED FROM 8 PLANTS/PLOT AT KENASTON, SASK.

DATE	PLOT 1	PLOT 2	PLOT 3	PLOT 4	MEAN	% INCREASE	CONVERSION Kg/ha (lbs/acre)
August 22	118	112	131	128	122.2 d	-	122 (85)
August 27	143	123	168	165	149.7 c	22	150 (104)
September 1	237	198	243	251	232.2 b	56	232 (160)
September 6	259	228	271	284	260.5 a	13	260 (180)

NOTES:

SEEDING DATE: May 23 SWATHED: September 1
TREATMENT MEANS GROUPED BY DUNCAN'S MULTIPLE RANGE TEST AT THE 5% LEVEL OF CONFIDENCE.

4. Swather Seed Catcher

Objective

To determine if catching seed dropped while swathing is economical.

Procedure

Borage must be swathed when some seeds are ripe and ready to fall off. Because these ripe seeds drop off and are lost in the swathing operation, a shaker feeder placed in the throat of the swather will catch the seed from the long canvases, and the seed that falls out of the material while forming the swath. The seed would then be carried by air to a separation cone which would act as a hopper. The system was tested and evaluated on the 1987 crop. It was built on a swather belonging to Howard Trischuk.

Results and Discussion

Initially, the seed catcher consisted of a large pan outfitted with lifters (beater bars) which were connected to a wheel drive. As the swather moved forward, the bars would lift the borage plants up and over the pan which would collect seeds dropped from the swath. Problems were encountered with this design as the borage plants became entangled within the lifters and clogged the mechanism. Various improvements and modifications were made to this design, but all proved unsatisfactory. Eventually, a design incorporating a canvas table with rollers was built (see attached photograph). A belt and pulley system permitted the canvas table to run simultaneously with the swather's own table. As the swath was collected, it would move over the attachment's table, and seeds dropping off would be collected at the rear of the pan. It was found that the mechanical agitation of the attachment's table was sufficient to dislodge the borage seeds from the swath. An adjustable finger type screen was located at the end to allow the seeds to

drop out into the catch tray. Tests need to be done to evaluate the effectiveness of the unit in separating the base seeds from the swath and catching them. Sixty acres of drought - damaged borage was harvested with the seed catcher at Saskatoon. The catcher collected an additional 10% of the total yield. In the initial trial at Wakaw, the seed catcher proved to be of greater value because yields were greater, thus a greater quantity of seeds were collected with the seed catcher. Report Number 4a deals with the economic viability of the swather attachment. We estimate the cost of the seed catcher to be about $ 1,000.^{00}. Because of time limitations and the extra work designing four different prototypes, the vacuum separator was not added to the system as previously proposed.

Recommendations

An air or auger type of seed lifter needs to be developed to continually empty the catcher of borage seed. It will have to incorporate a scalper to remove weed seeds and other trash from the sample. Rogers Engineering Inc. is willing to develop the unit with monies left over from the project, if it is requested.

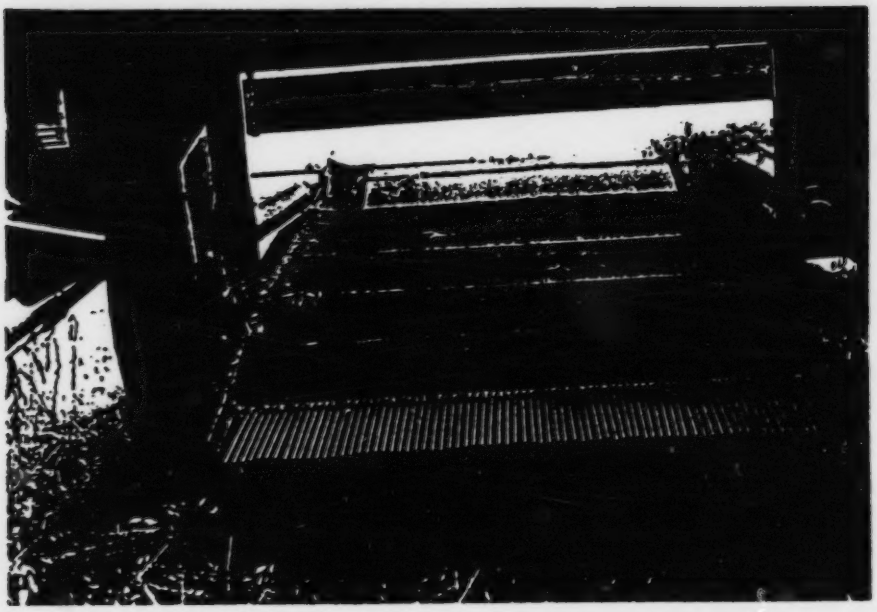


FIGURE 3: CANVAS TYPE BORAGE SEED CATCHER

FIGURE 4: LIFTER TYPE SEED CATCHER

4a. Economic Viability of a Swather Attachment to Catch Borage Seeds

Objective

To determine how much seed would be caught by an attachment to a swather while swathing, and thereby determining the economic feasibility of such an attachment.

Procedure

One-eighth (1/8) of an acre was swathed with the swather attachment catching the borage seeds. When the area was completed, the pan was cleaned. The material was then put through a combine. The borage was then cleaned and weighed. This trial was only done once as the shaker was taken back for modifications. The pan overflowed before the complete area was harvested, and some borage was lost.

Results and Calculations

- Uncleaned, the sample weight was: 875.60 g
- Cleaned, the sample weight was: 602.60 g

- The cleaned sample was then tested for dockage. The results were as follows:

Wt. of Sample (g)	Screenings (g)	Percent Dockage
5.06	.28	.056
5.01	.23	.046
5.01	.24	.048

Average = $\frac{\text{Sum (samples)}}{\text{No. of Samples}} = \frac{.15}{3}$ = 5% dockage

TOTAL WT. OF BORAGE = 602.6g x .95 = 572.47g

The moisture content was 13.5 percent.

Conclusion

The amount of borage saved per acre would be: **572.47 g x 8 = 4.57 kg**

At the 1987 price of borage ($ 8.00/kg), the amount of money saved per acre would be **$36.56.**

5. Moisture Testing

Introduction

Boerage seed needs to be stored at moisture contents of 10 percent or less, and previously, no charts are available to estimate mositure content using electrical capacitance. The Motomco meter was chosen because it is available at most country elevators, plus a S.E.D 35 was also calibrated.

Objective

To create a borage moisture content chart for the Motomco and S.E.D. 35 moisture meter.

Equipment

1. Motomco Model 919/3.5 (3.5" cell) Moisture Meter (Serial #T-2207)
2. SED-35 Moisture Meter
3. 1986 Borage Seed
4. Oven
5. Refrigerator
6. Themometers
7. Metric Digital Scale (Mettler PE 3600)
   - accurate to 1/100th of a gram

Procedure

1. The initial moisture content of a large sample of ('86) borage seed was determined by oven drying 25.00 g portions @ 200^{0} C for four hours.
2. Four 160.00 g samples were weighed out and labelled 101, 201, 301 and 401.
3. The moisture content of this first replicate was then lowered to approximately 7% (on a weight basis) by oven drying for a required length of time. The four samples were then placed in air tight flasks to avoid any further loss or gain of moisture.
4. Four more replicates (of 4- 160.00 g samples each) were weighed out and labelled 102->402, 103->403, 104->404 and 105->405, respectively.
5. The required amount of water was then added to the four samples of each replicate to raise their moisture content up to the approximate corresponding levels of 10, 13, 16 and 19%

(on a weight basis). These four replicates were then placed on a refrigerator @ 2^0 C for 48 hours in order to stabilize their new moisture levels (agitated frequently).

6. All five replicates (20 samples) were then stabilized at 10^0 C for 1-2 hours.
7. The samples were then tested following the revised operating instructions for both the Motomco and SED-35 moisture meters (see attached).
8. The meter readings and sample temperature were recorded for each replicate.
9. Steps 6-8 were then repeated for temperatures of 15, 20 and 25.
10. The exact moisture content of all twenty samples was then determined by oven drying 25.00 g portions @ 200^0 C for four hours. These values were recorded along with their corresponding sample number and meter readings.

Data Manipulation

11. The data for the Motomco meter was correlated using a computer program called Statsgraph. A multiple regression was performed manipulating temperature and meter reading versus moisture content producing an equation in the form: MC = MR (0.1828) - T (0.0849) and 9.228. The original 80 data points were expanded to produce a complete moisture content chart, ranging in temperature from $10-25^0$ C. and moisture content from 8% - 23%.

12. The data for the SED-35 meter was correlated using the same Statsgraph program. A simple regression was performed manipulating meter reading versus moisture content. The original 80 data points were expanded to produce a moisture content chart, ranging in moisture content from approximately 8.5% - 23%. The SED-35 meter was found to be independent upon sample temperature as long as the sample and meter were both in the same relative environment (temperature, humidity, etc.).

BORAGE MOISTURE TESTING

METER:

Motomco Model 919 (3.5" Dump Cell)

OPERATING PROCEDURE:

A) Calibration:

1) Attach the empty main cell to the meter.
2) Turn the power switch to the "ON" position.
3) Turn the function switch to the calibration (CAL) position.
4) Rotate the large knob until the dial reading of 100 is directly beneath the hairline.
5) Rotate the small knob until the meter needle reaches the lowest position (peaks out) on the scale.

NOTE: This procedure should be repeated at periodic intervals to compensate for changes in room temperature or humidity.

B) Moisture Determination:

6) Turn the function switch to the operate (OP) position.
7) Weigh out a 150.0 g sample and place it in the dump cell.
8) Place a thermometer in the dump cell along with the sample and note the reading after it has stabilized (1-2 mins.)
9) Remove the thermometer and place the dump over the main cell. Push the release button and remove the empty dump cell.
10) Rotate the large knob until the meter needle peaks out on the scale.
11) Note the dial reading directly beneath the hairline.
12) Apply this dial reading along with the sample temperature to the moisture content chart for Borage and read the corresponding percent moisture.
13) Procedure may be repeated using random samples to improve accuracy.

Rogers Engineering Inc.
Borage Moisture Content Chart
MOTOMCO Model 919/3.5
Aug 5, 1987

Meter Reading	Temperature (Degrees C) 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
5.0	9.29	9.21	9.12	9.04	8.95	8.87	8.78	8.70	8.61	8.53	8.44	8.36	8.27	8.19	8.10	8.02
5.5	9.38	9.30	9.21	9.13	9.04	8.96	8.87	8.79	8.70	8.62	8.53	8.45	8.36	8.28	8.19	8.11
6.0	9.48	9.39	9.31	9.22	9.14	9.05	8.97	8.88	8.80	8.71	8.63	8.54	8.46	8.37	8.29	8.20
6.5	9.57	9.48	9.40	9.31	9.23	9.14	9.06	8.97	8.89	8.80	8.72	8.63	8.55	8.46	8.38	8.29
7.0	9.66	9.57	9.49	9.40	9.32	9.23	9.15	9.06	8.98	8.89	8.81	8.72	8.64	8.55	8.47	8.38
7.5	9.75	9.66	9.58	9.49	9.41	9.32	9.24	9.15	9.07	8.98	8.90	8.81	8.73	8.64	8.56	8.47
8.0	9.84	9.76	9.67	9.59	9.50	9.42	9.33	9.25	9.16	9.08	8.99	8.91	8.82	8.74	8.65	8.57
8.5	9.93	9.85	9.76	9.68	9.59	9.51	9.42	9.34	9.25	9.17	9.08	9.00	8.91	8.83	8.74	8.66
9.0	10.02	9.94	9.85	9.77	9.68	9.60	9.51	9.43	9.34	9.26	9.17	9.09	9.00	8.92	8.83	8.75
9.5	10.11	10.03	9.94	9.86	9.77	9.69	9.61	9.52	9.44	9.35	9.27	9.18	9.10	9.01	8.93	8.84
10.0	10.21	10.12	10.04	9.95	9.87	9.78	9.70	9.61	9.53	9.44	9.36	9.27	9.19	9.10	9.02	8.93
10.5	10.30	10.21	10.13	10.04	9.96	9.87	9.79	9.70	9.62	9.53	9.45	9.36	9.28	9.19	9.11	9.02
11.0	10.39	10.30	10.22	10.13	10.05	9.96	9.88	9.79	9.71	9.62	9.54	9.45	9.37	9.28	9.20	9.11
11.5	10.48	10.40	10.31	10.23	10.14	10.06	9.97	9.89	9.80	9.72	9.63	9.55	9.46	9.38	9.29	9.21
12.0	10.57	10.49	10.40	10.32	10.23	10.15	10.06	9.98	9.89	9.81	9.72	9.64	9.55	9.47	9.38	9.30
12.5	10.66	10.58	10.49	10.41	10.32	10.24	10.15	10.07	9.98	9.90	9.81	9.73	9.64	9.56	9.47	9.39
13.0	10.75	10.67	10.58	10.50	10.41	10.33	10.24	10.16	10.07	9.99	9.90	9.82	9.73	9.65	9.56	9.48
13.5	10.85	10.76	10.68	10.59	10.51	10.42	10.34	10.25	10.17	10.08	10.00	9.91	9.83	9.74	9.66	9.57
14.0	10.94	10.85	10.77	10.68	10.60	10.51	10.43	10.34	10.26	10.17	10.09	10.00	9.92	9.83	9.75	9.66
14.5	11.03	10.94	10.86	10.77	10.69	10.60	10.52	10.43	10.35	10.26	10.18	10.09	10.01	9.92	9.84	9.75
15.0	11.12	11.04	10.95	10.87	10.78	10.70	10.61	10.53	10.44	10.36	10.27	10.19	10.10	10.02	9.93	9.85
15.5	11.21	11.13	11.04	10.96	10.87	10.79	10.70	10.62	10.53	10.45	10.36	10.28	10.19	10.11	10.02	9.94
16.0	11.30	11.22	11.13	11.05	10.96	10.88	10.79	10.71	10.62	10.54	10.45	10.37	10.28	10.20	10.11	10.03
16.5	11.39	11.31	11.22	11.14	11.05	10.97	10.88	10.80	10.71	10.63	10.54	10.46	10.37	10.29	10.20	10.12
17.0	11.49	11.40	11.32	11.23	11.15	11.06	10.98	10.89	10.81	10.72	10.64	10.55	10.47	10.38	10.30	10.21
17.5	11.58	11.49	11.41	11.32	11.24	11.15	11.07	10.98	10.90	10.81	10.73	10.64	10.56	10.47	10.39	10.30
18.0	11.67	11.58	11.50	11.41	11.33	11.24	11.16	11.07	10.99	10.90	10.82	10.73	10.65	10.56	10.48	10.39
18.5	11.76	11.68	11.59	11.51	11.42	11.34	11.25	11.17	11.08	11.00	10.91	10.83	10.74	10.66	10.57	10.49
19.0	11.85	11.77	11.68	11.60	11.51	11.43	11.34	11.26	11.17	11.09	11.00	10.92	10.83	10.75	10.66	10.58
19.5	11.94	11.86	11.77	11.69	11.60	11.52	11.43	11.35	11.26	11.18	11.09	11.01	10.92	10.84	10.75	10.67
20.0	12.03	11.95	11.86	11.78	11.69	11.61	11.52	11.44	11.35	11.27	11.18	11.10	11.01	10.93	10.84	10.76
20.5	12.13	12.04	11.96	11.87	11.79	11.70	11.62	11.53	11.45	11.36	11.28	11.19	11.11	11.02	10.94	10.85
21.0	12.22	12.13	12.05	11.96	11.88	11.79	11.71	11.62	11.54	11.45	11.37	11.28	11.20	11.11	11.03	10.94
21.5	12.31	12.22	12.14	12.05	11.97	11.88	11.80	11.71	11.63	11.54	11.46	11.37	11.29	11.20	11.12	11.03
22.0	12.40	12.32	12.23	12.15	12.06	11.98	11.89	11.81	11.72	11.64	11.55	11.47	11.38	11.30	11.21	11.13
22.5	12.49	12.41	12.32	12.24	12.15	12.07	11.98	11.90	11.81	11.73	11.64	11.56	11.47	11.39	11.30	11.22
23.0	12.58	12.50	12.41	12.33	12.24	12.16	12.07	11.99	11.90	11.82	11.73	11.65	11.56	11.48	11.39	11.31
23.5	12.67	12.59	12.50	12.42	12.33	12.25	12.16	12.08	11.99	11.91	11.82	11.74	11.65	11.57	11.48	11.40
24.0	12.77	12.68	12.60	12.51	12.43	12.34	12.26	12.17	12.09	12.00	11.92	11.83	11.75	11.66	11.58	11.49
24.5	12.86	12.77	12.69	12.60	12.52	12.43	12.35	12.26	12.18	12.09	12.01	11.92	11.84	11.75	11.67	11.58
25.0	12.95	12.86	12.78	12.69	12.61	12.52	12.44	12.35	12.27	12.18	12.10	12.01	11.93	11.84	11.76	11.67
25.5	13.04	12.96	12.87	12.79	12.70	12.62	12.53	12.45	12.36	12.28	12.19	12.11	12.02	11.94	11.85	11.77
26.0	13.13	13.05	12.96	12.88	12.79	12.71	12.62	12.54	12.45	12.37	12.28	12.20	12.11	12.03	11.94	11.86
26.5	13.22	13.14	13.05	12.97	12.88	12.80	12.71	12.63	12.54	12.46	12.37	12.29	12.20	12.12	12.03	11.95
27.0	13.31	13.23	13.14	13.06	12.97	12.89	12.80	12.72	12.63	12.55	12.46	12.38	12.29	12.21	12.12	12.04
27.5	13.41	13.32	13.24	13.15	13.07	12.98	12.90	12.81	12.73	12.64	12.56	12.47	12.39	12.30	12.22	12.13
28.0	13.50	13.41	13.33	13.24	13.16	13.07	12.99	12.90	12.82	12.73	12.65	12.56	12.48	12.39	12.31	12.22
28.5	13.59	13.50	13.42	13.33	13.25	13.16	13.08	12.99	12.91	12.82	12.74	12.65	12.57	12.48	12.40	12.31

Rogers Engineering Inc.
Borage Moisture Content Chart
HOTOMCO Model 919/3.5
Aug 5, 1987

Meter Reading	Temperature (Degrees C) 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
29.0	13.68	13.60	13.51	13.43	13.34	13.26	13.17	13.09	13.00	12.92	12.83	12.75	12.66	12.58	12.49	12.41
29.5	13.77	13.69	13.60	13.52	13.43	13.35	13.26	13.18	13.09	13.01	12.92	12.84	12.75	12.67	12.58	12.50
30.0	13.86	13.78	13.69	13.61	13.52	13.44	13.35	13.27	13.18	13.10	13.01	12.93	12.84	12.76	12.67	12.59
30.5	13.95	13.87	13.78	13.70	13.61	13.53	13.44	13.36	13.27	13.19	13.10	13.02	12.93	12.85	12.76	12.68
31.0	14.05	13.96	13.88	13.79	13.71	13.62	13.54	13.45	13.37	13.28	13.20	13.11	13.03	12.94	12.86	12.77
31.5	14.14	14.05	13.97	13.88	13.80	13.71	13.63	13.54	13.46	13.37	13.29	13.20	13.12	13.03	12.95	12.86
32.0	14.23	14.14	14.06	13.97	13.89	13.80	13.72	13.63	13.55	13.46	13.38	13.29	13.21	13.12	13.04	12.95
32.5	14.32	14.23	14.15	14.06	13.98	13.89	13.81	13.72	13.64	13.56	13.47	13.39	13.30	13.22	13.13	13.05
33.0	14.41	14.33	14.24	14.16	14.07	13.99	13.90	13.82	13.73	13.65	13.56	13.48	13.39	13.31	13.22	13.14
33.5	14.50	14.42	14.33	14.25	14.16	14.08	13.99	13.91	13.82	13.74	13.65	13.57	13.48	13.40	13.31	13.23
34.0	14.59	14.51	14.42	14.34	14.25	14.17	14.08	14.00	13.91	13.83	13.74	13.66	13.57	13.49	13.40	13.32
34.5	14.69	14.60	14.52	14.43	14.35	14.26	14.18	14.09	14.01	13.92	13.84	13.75	13.67	13.58	13.50	13.41
35.0	14.78	14.69	14.61	14.52	14.44	14.35	14.27	14.18	14.10	14.01	13.93	13.84	13.76	13.67	13.59	13.50
35.5	14.87	14.78	14.70	14.61	14.53	14.44	14.36	14.27	14.19	14.10	14.02	13.93	13.85	13.76	13.68	13.59
36.0	14.96	14.87	14.79	14.70	14.62	14.53	14.45	14.36	14.28	14.19	14.11	14.02	13.94	13.85	13.77	13.68
36.5	15.05	14.97	14.88	14.80	14.71	14.63	14.54	14.46	14.37	14.29	14.20	14.12	14.03	13.95	13.86	13.78
37.0	15.14	15.06	14.97	14.89	14.80	14.72	14.63	14.55	14.46	14.38	14.29	14.21	14.12	14.04	13.95	13.87
37.5	15.23	15.15	15.06	14.98	14.89	14.81	14.72	14.64	14.55	14.47	14.38	14.30	14.21	14.13	14.04	13.96
38.0	15.33	15.24	15.16	15.07	14.99	14.90	14.82	14.73	14.65	14.56	14.48	14.39	14.31	14.22	14.14	14.05
38.5	15.42	15.33	15.25	15.16	15.08	14.99	14.91	14.82	14.74	14.65	14.57	14.48	14.40	14.31	14.23	14.14
[illegible].0	15.51	15.42	15.34	15.25	15.17	15.08	15.00	14.91	14.83	14.74	14.66	14.57	14.49	14.40	14.32	14.23
..5	15.60	15.51	15.43	15.34	15.26	15.17	15.09	15.00	14.92	14.83	14.75	14.66	14.58	14.49	14.41	14.32
40.0	15.69	15.61	15.52	15.44	15.35	15.27	15.18	15.10	15.01	14.93	14.84	14.76	14.67	14.59	14.50	14.42
40.5	15.78	15.70	15.61	15.53	15.44	15.36	15.27	15.19	15.10	15.02	14.93	14.85	14.76	14.68	14.59	14.51
41.0	15.87	15.79	15.70	15.62	15.53	15.45	15.36	15.28	15.19	15.11	15.02	14.94	14.85	14.77	14.68	14.60
41.5	15.97	15.88	15.80	15.71	15.63	15.54	15.46	15.37	15.29	15.20	15.12	15.03	14.95	14.86	14.78	14.69
42.0	16.06	15.97	15.89	15.80	15.72	15.63	15.55	15.46	15.38	15.29	15.21	15.12	15.04	14.95	14.87	14.78
42.5	16.15	16.06	15.98	15.89	15.81	15.72	15.64	15.55	15.47	15.38	15.30	15.21	15.13	15.04	14.96	14.87
43.0	16.24	16.15	16.07	15.98	15.90	15.81	15.73	15.64	15.56	15.47	15.39	15.30	15.22	15.13	15.05	14.96
43.5	16.33	16.25	16.16	16.08	15.99	15.91	15.82	15.74	15.65	15.57	15.48	15.40	15.31	15.23	15.14	15.06
44.0	16.42	16.34	16.25	16.17	16.08	16.00	15.91	15.83	15.74	15.66	15.57	15.49	15.40	15.32	15.23	15.15
44.5	16.51	16.43	16.34	16.26	16.17	16.09	16.00	15.92	15.83	15.75	15.66	15.58	15.49	15.41	15.32	15.24
45.0	16.61	16.52	16.44	16.35	16.27	16.18	16.10	16.01	15.93	15.84	15.76	15.67	15.59	15.50	15.42	15.33
45.5	16.70	16.61	16.53	16.44	16.36	16.27	16.19	16.10	16.02	15.93	15.85	15.76	15.68	15.59	15.51	15.42
46.0	16.79	16.70	16.62	16.53	16.45	16.36	16.28	16.19	16.11	16.02	15.94	15.85	15.77	15.68	15.60	15.51
46.5	16.88	16.79	16.71	16.62	16.54	16.45	16.37	16.28	16.20	16.11	16.03	15.94	15.86	15.77	15.69	15.60
47.0	16.97	16.89	16.80	16.72	16.63	16.55	16.46	16.38	16.29	16.21	16.12	16.04	15.95	15.87	15.78	15.70
47.5	17.06	16.98	16.89	16.81	16.72	16.64	16.55	16.47	16.38	16.30	16.21	16.13	16.04	15.96	15.87	15.79
48.0	17.15	17.07	16.98	16.90	16.81	16.73	16.64	16.56	16.47	16.39	16.30	16.22	16.13	16.05	15.96	15.88
48.5	17.25	17.16	17.08	16.99	16.91	16.82	16.74	16.65	16.57	16.48	16.40	16.31	16.23	16.14	16.06	15.97
49.0	17.34	17.25	17.17	17.08	17.00	16.91	16.83	16.74	16.66	16.57	16.49	16.40	16.32	16.23	16.15	16.06
49.5	17.43	17.34	17.26	17.17	17.09	17.00	16.92	16.83	16.75	16.66	16.58	16.49	16.41	16.32	16.24	16.15
50.0	17.52	17.43	17.35	17.26	17.18	17.09	17.01	16.92	16.84	16.75	16.67	16.58	16.50	16.41	16.33	16.24
50.5	17.61	17.53	17.44	17.36	17.27	17.19	17.10	17.02	16.93	16.85	16.76	16.68	16.59	16.51	16.42	16.34
51.0	17.70	17.62	17.53	17.45	17.36	17.28	17.19	17.11	17.02	16.94	16.85	16.77	16.68	16.60	16.51	16.43
51.5	17.79	17.71	17.62	17.54	17.45	17.37	17.28	17.20	17.11	17.03	16.94	16.86	16.77	16.69	16.60	16.52
[illegible].0	17.88	17.80	17.71	17.63	17.55	17.46	17.38	17.29	17.21	17.12	17.04	16.95	16.87	16.78	16.70	16.61
52.5	17.98	17.89	17.81	17.72	17.64	17.55	17.47	17.38	17.30	17.21	17.13	17.04	16.96	16.87	16.79	16.70

Rogers Engineering Inc.
Borage Moisture Content Chart
MOTOMCO Model 919/3.5
Aug 5, 1987

Meter Reading	Temperature (Degrees C) 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
53.0	18.07	17.98	17.90	17.81	17.73	17.64	17.56	17.47	17.39	17.30	17.22	17.13	17.05	16.96	16.88	16.79
53.5	18.16	18.07	17.99	17.90	17.82	17.73	17.65	17.56	17.48	17.39	17.31	17.22	17.14	17.05	16.97	16.88
54.0	18.25	18.17	18.08	18.00	17.91	17.83	17.74	17.66	17.57	17.49	17.40	17.32	17.23	17.15	17.06	16.98
54.5	18.34	18.26	18.17	18.09	18.00	17.92	17.83	17.75	17.66	17.58	17.49	17.41	17.32	17.24	17.15	17.07
55.0	18.43	18.35	18.26	18.18	18.09	18.01	17.92	17.84	17.75	17.67	17.58	17.50	17.41	17.33	17.24	17.16
55.5	18.52	18.44	18.35	18.27	18.18	18.10	18.01	17.93	17.84	17.76	17.67	17.59	17.50	17.42	17.34	17.25
56.0	18.62	18.53	18.45	18.36	18.28	18.19	18.11	18.02	17.94	17.85	17.77	17.68	17.60	17.51	17.43	17.34
56.5	18.71	18.62	18.54	18.45	18.37	18.28	18.20	18.11	18.03	17.94	17.86	17.77	17.69	17.60	17.52	17.43
57.0	18.80	18.71	18.63	18.54	18.46	18.37	18.29	18.20	18.12	18.03	17.95	17.86	17.78	17.69	17.61	17.52
57.5	18.89	18.81	18.72	18.64	18.55	18.47	18.38	18.30	18.21	18.13	18.04	17.96	17.87	17.79	17.70	17.62
58.0	18.98	18.90	18.81	18.73	18.64	18.56	18.47	18.39	18.30	18.22	18.13	18.05	17.96	17.88	17.79	17.71
58.5	19.07	18.99	18.90	18.82	18.73	18.65	18.56	18.48	18.39	18.31	18.22	18.14	18.05	17.97	17.88	17.80
59.0	19.16	19.08	18.99	18.91	18.82	18.74	18.65	18.57	18.48	18.40	18.31	18.23	18.14	18.06	17.97	17.89
59.5	19.26	19.17	19.09	19.00	18.92	18.83	18.75	18.66	18.58	18.49	18.41	18.32	18.24	18.15	18.07	17.98
60.0	19.35	19.26	19.18	19.09	19.01	18.92	18.84	18.75	18.67	18.58	18.50	18.41	18.33	18.24	18.16	18.07
60.5	19.44	19.35	19.27	19.18	19.10	19.01	18.93	18.84	18.76	18.67	18.59	18.50	18.42	18.33	18.25	18.16
61.0	19.53	19.45	19.36	19.28	19.19	19.11	19.02	18.94	18.85	18.77	18.68	18.60	18.51	18.43	18.34	18.26
61.5	19.62	19.54	19.45	19.37	19.28	19.20	19.11	19.03	18.94	18.86	18.77	18.69	18.60	18.52	18.43	18.35
62.0	19.71	19.63	19.54	19.46	19.37	19.29	19.20	19.12	19.03	18.95	18.86	18.78	18.69	18.61	18.52	18.44
62.5	19.80	19.72	19.63	19.55	19.46	19.38	19.29	19.21	19.12	19.04	18.95	18.87	18.78	18.70	18.61	18.53
63.0	19.90	19.81	19.73	19.64	19.56	19.47	19.39	19.30	19.22	19.13	19.05	18.96	18.88	18.79	18.71	18.62
63.5	19.99	19.90	19.82	19.73	19.65	19.56	19.48	19.39	19.31	19.22	19.14	19.05	18.97	18.88	18.80	18.71
64.0	20.08	19.99	19.91	19.82	19.74	19.65	19.57	19.48	19.40	19.31	19.23	19.14	19.06	18.97	18.89	18.80
64.5	20.17	20.09	20.00	19.92	19.83	19.75	19.66	19.58	19.49	19.41	19.32	19.24	19.15	19.07	18.98	18.90
65.0	20.26	20.18	20.09	20.01	19.92	19.84	19.75	19.67	19.58	19.50	19.41	19.33	19.24	19.16	19.07	18.99
65.5	20.35	20.27	20.18	20.10	20.01	19.93	19.84	19.76	19.67	19.59	19.50	19.42	19.33	19.25	19.16	19.08
66.0	20.44	20.36	20.27	20.19	20.10	20.02	19.93	19.85	19.76	19.68	19.59	19.51	19.42	19.34	19.25	19.17
66.5	20.54	20.45	20.37	20.28	20.20	20.11	20.03	19.94	19.86	19.77	19.69	19.60	19.52	19.43	19.35	19.26
67.0	20.63	20.54	20.46	20.37	20.29	20.20	20.12	20.03	19.95	19.86	19.78	19.69	19.61	19.52	19.44	19.35
67.5	20.72	20.63	20.55	20.46	20.38	20.29	20.21	20.12	20.04	19.95	19.87	19.78	19.70	19.61	19.53	19.44
68.0	20.81	20.73	20.64	20.56	20.47	20.39	20.30	20.22	20.13	20.05	19.96	19.88	19.79	19.71	19.62	19.54
68.5	20.90	20.82	20.73	20.65	20.56	20.48	20.39	20.31	20.22	20.14	20.05	19.97	19.88	19.80	19.71	19.63
69.0	20.99	20.91	20.82	20.74	20.65	20.57	20.48	20.40	20.31	20.23	20.14	20.06	19.97	19.89	19.80	19.72
69.5	21.08	21.00	20.91	20.83	20.74	20.66	20.57	20.49	20.40	20.32	20.23	20.15	20.06	19.98	19.89	19.81
70.0	21.18	21.09	21.01	20.92	20.84	20.75	20.67	20.58	20.50	20.41	20.33	20.24	20.16	20.07	19.99	19.90
70.5	21.27	21.18	21.10	21.01	20.93	20.84	20.76	20.67	20.59	20.50	20.42	20.33	20.25	20.16	20.08	19.99
71.0	21.36	21.27	21.19	21.10	21.02	20.93	20.85	20.76	20.68	20.59	20.51	20.42	20.34	20.25	20.17	20.08
71.5	21.45	21.37	21.28	21.20	21.11	21.03	20.94	20.86	20.77	20.69	20.60	20.52	20.43	20.35	20.26	20.18
72.0	21.54	21.46	21.37	21.29	21.20	21.12	21.03	20.95	20.86	20.78	20.69	20.61	20.52	20.44	20.35	20.27
72.5	21.63	21.55	21.46	21.38	21.29	21.21	21.12	21.04	20.95	20.87	20.78	20.70	20.61	20.53	20.44	20.36
73.0	21.72	21.64	21.55	21.47	21.38	21.30	21.21	21.13	21.04	20.96	20.87	20.79	20.70	20.62	20.53	20.45
73.5	21.82	21.73	21.65	21.56	21.48	21.39	21.31	21.22	21.14	21.05	20.97	20.88	20.80	20.71	20.63	20.54
74.0	21.91	21.82	21.74	21.65	21.57	21.48	21.40	21.31	21.23	21.14	21.06	20.97	20.89	20.80	20.72	20.63
74.5	22.00	21.91	21.83	21.74	21.66	21.57	21.49	21.40	21.32	21.23	21.15	21.06	20.98	20.89	20.81	20.72
75.0	22.09	22.00	21.92	21.83	21.75	21.66	21.58	21.50	21.41	21.33	21.24	21.16	21.07	20.99	20.90	20.82
75.5	22.18	22.10	22.01	21.93	21.84	21.76	21.67	21.59	21.50	21.42	21.33	21.25	21.16	21.08	20.99	20.91
76.0	22.27	22.19	22.10	22.02	21.93	21.85	21.76	21.68	21.59	21.51	21.42	21.34	21.25	21.17	21.08	21.00
76.5	22.36	22.28	22.19	22.11	22.02	21.94	21.85	21.77	21.68	21.60	21.51	21.43	21.34	21.26	21.17	21.09

Rogers Engineering Inc.
Borage Moisture Content Chart
HOTOMCO Model 919/3.5
Aug 3, 1987

Meter Reading	Temperature (Degrees C) 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
77.0	22.46	22.37	22.29	22.20	22.12	22.03	21.95	21.86	21.78	21.69	21.61	21.52	21.44	21.35	21.27	21.18
77.5	22.55	22.46	22.38	22.29	22.21	22.12	22.04	21.95	21.87	21.78	21.70	21.61	21.53	21.44	21.36	21.27
78.0	22.64	22.55	22.47	22.38	22.30	22.21	22.13	22.04	21.96	21.87	21.79	21.70	21.62	21.53	21.45	21.36
78.5	22.73	22.64	22.56	22.47	22.39	22.30	22.22	22.13	22.05	21.96	21.88	21.79	21.71	21.62	21.54	21.45
79.0	22.82	22.74	22.65	22.57	22.48	22.40	22.31	22.23	22.14	22.06	21.97	21.89	21.80	21.72	21.63	21.55
79.5	22.91	22.83	22.74	22.66	22.57	22.49	22.40	22.32	22.23	22.15	22.06	21.98	21.89	21.81	21.72	21.64
80.0	23.00	22.92	22.83	22.75	22.66	22.58	22.49	22.41	22.32	22.24	22.15	22.07	21.98	21.90	21.81	21.73

BORAGE MOISTURE TESTING

METER:

SED-35

OPERATING PROCEDURE:

1) Follow the procedure as outlined in the SED-35 instruction booklet using the arbitrary scale on the tester.
2) Once a reading is obtained, refer to the moisture content chart for Borage and read off the corresponding percent moisture.
3) Apply the temperature correction factor found by the slide rule, if applicable.